The Mexico Competitiveness Report 2009

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CHAPTER 2.5

Producing Superstars for the Economic *Mundial*: The Mexican Predicament with Quality of Education

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Although we are leery of comparing economic competition to athletic competition, we want to use the metaphor of the *Mundial de fútbol* to illustrate three points. First, in a *Mundial,* global competitiveness matters because it stacks players of different countries up against each other on a level playing field. While victory in any given league is relative, one can be the best in a local league without being very good. Second, in the *Mundial* it is not the *average* quality of the players that matters, it is the very upper tail — the best of the best. The quality of the players in the upper tail depends not just on the average of the distribution, but also on how that distribution is shaped — its variance and whether it is skewed toward the upper, high-performance tail. Third, the simple math of order statistics suggests that the absolute quality of the players depends in part on the size of the pool from which they are drawn — in a random drawing of standard normal variates, the best of 100 will be around 2.5, but the best of a million will be around 4.9. Every boy in Mexico believes that he is in the running to be selected for the *Mundial*, but can the same be said for the economic *Mundial* — does every child really believe that he or she has a shot at rising to the best of the best economically?

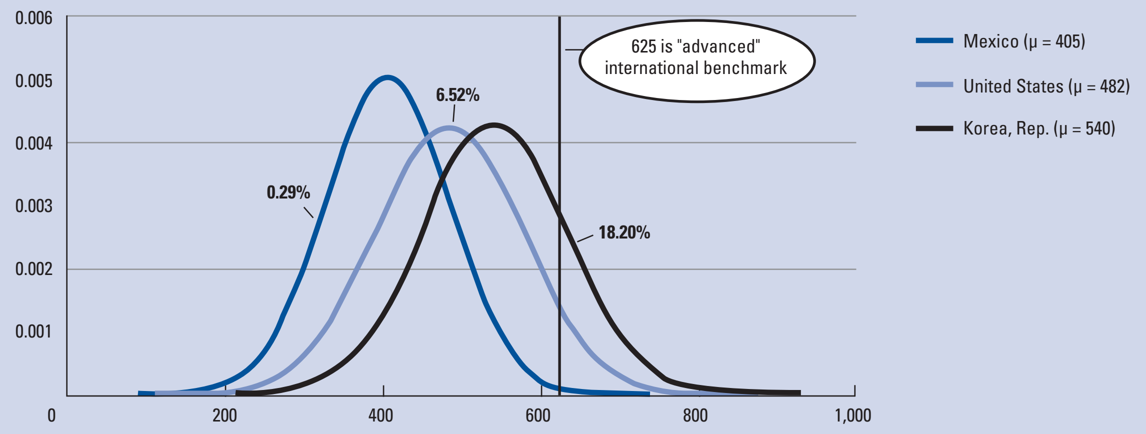
The quality of Mexican education in an international context

The low rates of school enrollment and educational attainment of the Mexican population are widely acknowledged: out of every 100 students entering primary school, 68 complete their basic compulsory education whereas only 35 graduate from upper secondary school.[1] Only 8.5% of the population aged 18 and older held a Bachelor degree in 2003.[2] However, more recent economic research has shown that what really plays a role in determining a country's competitiveness and economic growth is the level of cognitive skills of the labor force rather than its level of schooling.[3] That is, the *quality* of education is more important than the mere expansion of schooling opportunities (i.e., the quantity of education, measured by number of years of schooling). But this research also suggests that it is not just the average quality that matters, but the quality at the top as well. In this section we examine how Mexico performs vis-à-vis the world in terms of standards of education at the secondary — both on average and at the top — and higher levels.

Quality of education at the secondary level: Average and upper tail

In order to examine the quality of Mexican secondary education, we compare it to international secondary education standards. In this regard, the Programme for International Student Assessment (PISA) test of the Organisation for Economic Co-operation and

Figure 1 Distribution of test scores in the PISA 2003 mathematics assessment



Source: PISA 2003 International Database

Development (OECD) allows for a consistent comparison across countries because it provides comparable measures of the knowledge acquired by 15-year-old students who are close to the end of compulsory schooling in the majority of the participating countries.[4] Moreover, the test is not curriculum-based (as is, for instance, the Trends in International Mathematics and Science Study, or TIMSS test). The focus of the PISA text is on "what people can do" rather than "what people know" — and while there are arguments for both types of tests, for our purposes the PISA raises fewer questions about the results that are caused by differences in curricular content.

The PISA evaluates how educational systems prepare students for life in a larger context. In Figure 1, we compare Mexico's distribution of test scores in mathematics with those of the United States and Korea, Rep. (Korea).[5] Test scores have been standardized, so that the OECD-wide mean is equal to 500 and the OECD-wide student standard deviation equal to 100. The designers of the PISA test also distinguish six levels of proficiency.[6] An example of the sample questions in mathematics is provided in Table A2 in Annex A.

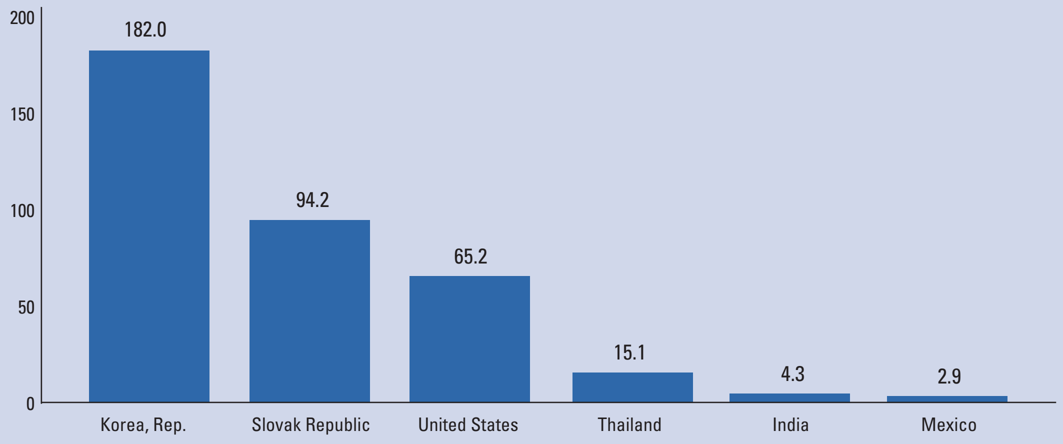
The average Mexican student is performing significantly below the OECD average, far from his Korean and American counterparts, and also below Turkish and Thai students.[7] That is, the average Mexican student achieves only Proficiency Level 1 in mathematics, which means they cannot do more than "carry out routine procedures according to direct instructions in explicit situations."[8] We do not dwell on the average score, as Mexico's lagging behind other nations on average in learning competencies in fields like mathematics and science is not news. We focus instead on two features that the comparison of averages across countries does not highlight: the upper tail and the *absolute number* (not percent) of high performers.

A test score higher than 625 is considered to be "advanced" by PISA international standards. This is, by construction, 1.25 standard deviations above the OECD mean. This is the score near the middle of students in Proficiency Level 5 (from 607 to 668). Students above this benchmark of proficiency are capable, among other things, "of advanced mathematical thinking and reasoning and can interpret complex information about real-world situations."[9] Figure 1 shows that only 0.29% of students who took the test have performed above the advanced international benchmark. This compares with 18.2% of those tested in Korea and 6.5% in the United States, implying that only 3 in 1,000 Mexican 15-year-olds tested were "advanced" or above in mathematics. This is compared with roughly 100 in 1,000 above that threshold in all OECD countries.[10]

If we compare Mexico's production of global performers per 1,000 people in the cohort, we find this number to be extremely low for Mexico (Figure 2). Again, the OECD standard is roughly 105 per 1,000; Korea is well above that level, the Slovak Republic just below, and Thailand is far below that level, with only 15 students per 1,000. But this is still five times higher than Mexico's level of 2.9 per 1,000. India has not participated in the TIMSS, but recently researchers have attempted to compare India's performance with other countries using matched questions for two states and extrapolating, in this case from TIMSS comparable questions, but normalized in the same way to be crudely comparable. India, whose *average* is much lower than Mexico's, still had a higher proportion above the threshold than Mexico.

Making scores comparable across countries implies that usually the results are reported as percents or summary statistics of scores, which do not depend on absolute numbers. However, it might be of interest to know how many students are above a particular threshold. The very small share of students at the top of the distribution implies a small absolute number of students above the advanced international benchmark. The diffi-

Figure 2 Number out of 1,000 students estimated to be above 625 on PISA 2003 in mathematics (except for India)



Source: Authors' calculations

culty is that we have only actual information on the tested population, which was intended to be a random sample of those in school. We can make two alternative assumptions. One is that the same proportion of the non-tested students would have scored above the threshold as tested students. This gives an upper bound on the total. Alternatively, we can assume that none of the students not in school at age 15 would have scored above 625 if tested. In this case, we calculate the total number by multiplying the cohort size by the gross enrollment in secondary schools to estimate the total enrolled population. This gives us a lower bound on total number. Work done in other contexts suggests that, for Mexico, the true number is more likely near the lower bound than the upper bound as few dropouts would be above the upper bound.[11]

Table 1 shows that, based on the lower-bound estimates, around 3,500 students are above the advanced international standard, and even on the very optimistic assumptions of the upper bound, the number is only 5,822. Of 2 million 15-year-olds in Mexico, every student who attains higher than an advanced standard could fit in a small auditorium. There are many other countries that also have small absolute numbers, and we calculated a similar figure for India, Korea, the Slovak Republic, Thailand, and the United States.

The Slovak Republic — a small country that provides an education roughly equivalent in quality to education in the average OECD country — with only 85,000 in its cohort produces more global performers than Mexico. Thailand is an emerging middle-income country (its average GDP per capita is below Mexico's) without particularly stellar schooling, but it produces over 10,000 students who perform above an advanced standard per year. Korea is renowned for academic excellence in at least one area, and with only 700,000 students it produces 124,000 who test above this advanced standard. The United States does not have good test scores by OECD standards but still produces almost a quarter of a million students a year with this level of capability. This means that for every Mexican 15-year-old who achieves a score above 625 there are 69 American students above that standard.

For India we only have very crude calculations,[12] but the comparison is very instructive, particularly given India's sustained rapid growth and strong emergence in

Table 1 Estimates of total number scoring above 625 on PISA 2003 in mathematics, selected countries

Country	Cohort size of 15-year-olds	Gross enrollment rate in secondary school	Estimated number of test takers (enrolled 15-year-olds)	Test takers per 100 students above the "advanced international benchmark" of 625 in mathematics	Estimated absolute number of students above threshold	
					Lower bound	Upper bound
	A	B	C	D	C x D	A x D
Mexico	2,007,721	60.00	1,204,632	0.29	3,493	5,822
Slovak Republic	85,095	75.00	63,821	9.42	6,012	8,016
Thailand	1,021,145	71.20	727,055	1.51	10,979	15,419
India*	21,994,737	52.30	11,503,247	0.83	95,659	182,904
Korea, Rep.	701,056	97.20	681,426	18.20	124,020	127,592
United States	4,178,014	88.00	3,676,652	6.52	239,718	272,407

*India has neither PISA nor TIMSS results, but a recent paper was able to estimate this number based on matching TIMSS methods. The percent is derived backward from the rawlower-bound estimate.

Table 2 Average national scores of the six contestants in the International Mathematical Olympiad, 2001–07

Country	Average score (out of 42 possible) of each eligible student	Size of cohort of 15-year-olds
Mexico	13.3	2,007,721
Slovak Republic	15.9	85,095
Thailand	19.2	1,021,145
India	21.3	21,994,737
Korea, Rep.	28.0	701,056
United States	29.9	4,178,014
China	35.1	20,215,800

Source: Results of International Mathematical Olympiad 2001–04, 2006–07

information technology and many science-related fields. The basic educational system in India (at the primary and junior secondary levels) is extremely weak on average. A variety of recent assessments have shown that the typical Indian primary school child has extremely weak learning performance — much worse than Mexico. However, at the same time, at the higher levels there is strong competitive pressure for the student examinations at grade 10 (for eligibility for 11th and 12th grades) and for university admission. This means that the upper tail has maintained very tough standards, a very high level of private-sector participation, and very high student effort. Thus, although India has very weak *typical* student performance, the upper tail is much more substantial than one might expect. That, combined with a large cohort, results in the fact that India produces roughly 100,000 students per year above this global benchmark — 27 times as many as Mexico.

One way to illustrate the average ability of the best performers is to calculate, as we have done in this chapter, the fraction above some threshold. The other way is to compare the differences in performance of the very top performers. The International Mathematical Olympiad is a competition held every year for high school students. Each country can send up to six contestants, who are each given six very difficult questions. Their answers are marked from 0 to 7 (with 7 being the highest possible mark), so that the maximum score for any individual student is 42 points. Table 2 shows the average score per eligible student for 2000–07 (except 2005) for each of the countries in Table 1, plus China.[13] If one assumes that the process of choosing the national contestants is reasonably effective, then this is a comparison of how good the very best of each country's aspiring mathematicians are. As we see, these results are ordered exactly the same as the estimates of the number of students above the threshold. The typical Mexican contestant scores about as well as the typical Slovakian contestant, only half as well as the typical Korean, and almost a third as well as the typical Chinese contestant. Again, India — although it has worse education indicators on average than the other countries considered — outperforms at the top, in this case likely because of its large size.

These results need to be read keeping in mind the properties of order statistics. If two countries have identical means and variances but different sizes, then the large country would be expected to perform better at the top simply because of the larger sample from which it is drawn. The fact that the Slovak Republic produces six students who outperform the Mexican six is striking because the former has more than 20 times fewer high school–aged students from which to generate the six. Therefore the modestly better scores in the Olympiad are consistent with substantially better typical performance.[14]

We are not suggesting that mathematics alone is particularly central to either academic or economic performance. We did these same calculations with both PISA reading and science scores with similar results. Nor is there anything particularly important about the benchmark score of 625 that we use. Mathematics and the 625 score are used to illustrate two issues that have been insufficiently stressed in the discussion about education quality; these apply to any subject or any threshold.

The first issue is that low averages are not *just* low averages. A low average score without an elongated upper tail implies that proportionately very few students are high performers by an absolute or international standard of performance. This means the top Mexican students will be only at a level that is quite common in better-performing countries.

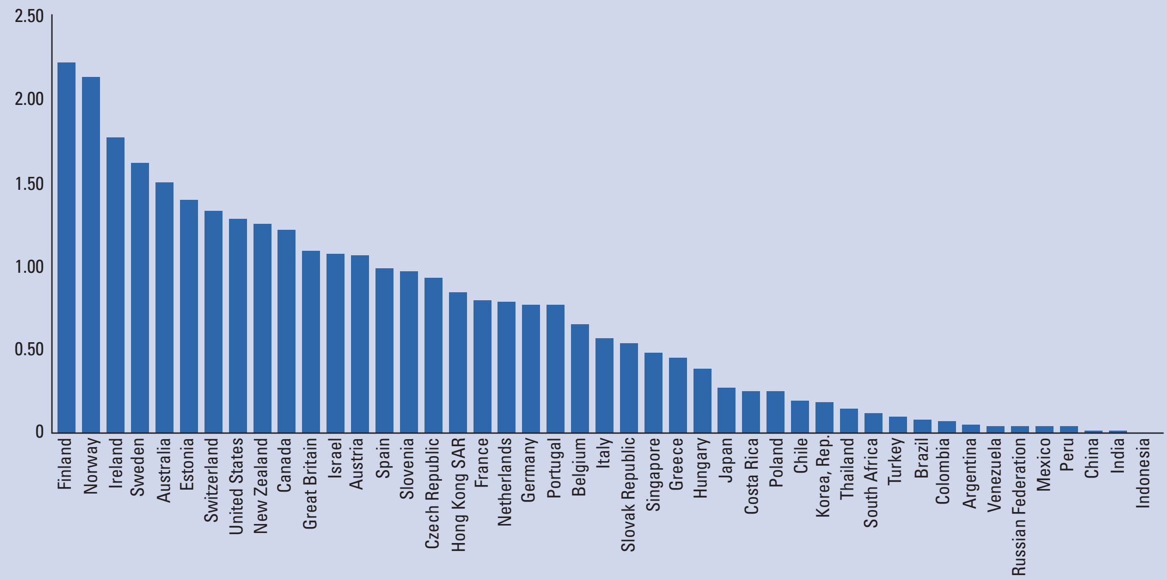
The second issue is that of the absolute numbers of high performers. Only a very few Mexican students are ready to go to college and to compete internationally.

Low quality at higher levels of education

One might conjecture that the deficiencies in the quality of secondary students' performance are made up for in higher education. This is almost certainly not true, especially if the comparison is with students in the United States. It is of course very difficult to rank institutions of higher education, and one must take existing rankings with considerable caution. However, the broad pattern is so striking it is unlikely that other methods would overturn its results.

According to the Shanghai Academic Ranking of Top World Universities, there is only *one* Mexican university in the top 500 — *Universidad Nacional Autónoma*

Figure 3 Ranking of universities based on Web visibility, numbers of universities in top 1,000 worldwide per million population



Source: Authors' calculations

de México (UNAM), which ranks 185, between the University of Miami and the University of Nebraska at Lincoln. This ranking assesses broad-based universities based on their faculty, facilities, research, and so on. Of course it omits several Mexican institutions of higher education that almost certainly are of high quality but may be too specialized to make a list aimed at assessing general universities (such as ITAM or Monterrey Tech). But even if one were to add these, the point remains that the *typical* higher education experience in Mexico is unlikely to overcome initial gaps — if anything, it exacerbates them.

There are other rankings of top universities. According to the London Times Higher Education Supplement 2007 (THES-QS), of the top 400 institutions of higher education, Korea has seven, Brazil has three, and Mexico only one. Again, UNAM enters into the ranking at 192. Not only do Mexican universities not rank with the world's best (in the top 20 are universities from the United States, the United Kingdom, Australia, Japan, Hong Kong, and Canada), but they are not superior to middle-tier US universities that round out the 400 — such as the University of Kentucky, Georgia State, and the University of Missouri.

The third global ranking focuses on the universities' Web presence. This ranking is probably also distorted in various ways, but it provides a cross-check on the others and enables us to go into more detail. If we look at the number of Mexican universities in the top 1,000 with a Web presence, we only find four Mexican institutions, or only 1 per 25,000,000 people (Figure 3). This implies that the very small number of secondary school students who perform at a globally competitive level do not have the chance to receive instruction from world-class universities. At best, those high achievers can benefit from an average tertiary education.

Moreover, education research in Mexico is still very limited. On a per capita basis, Mexico produces a very small number of highly qualified workers: in 2002, Mexico graduated 1.4 PhDs per million inhabitants, compared to 22 PhDs in the United States.[15] And out of more than 200 graduate programs, only 4 are recognized by the *Consejo Nacional de Ciencia y Tecnología* to be of high quality by international standards.

Of course this examines only domestic universities. Many Mexicans seek degrees in the United States or the United Kingdom, or other destinations. In 2006–07, about 14,000 Mexican students were estimated to be studying in the United States (only some of these were undergraduates). This still remains a small fraction of the overall education outcomes in the United States.

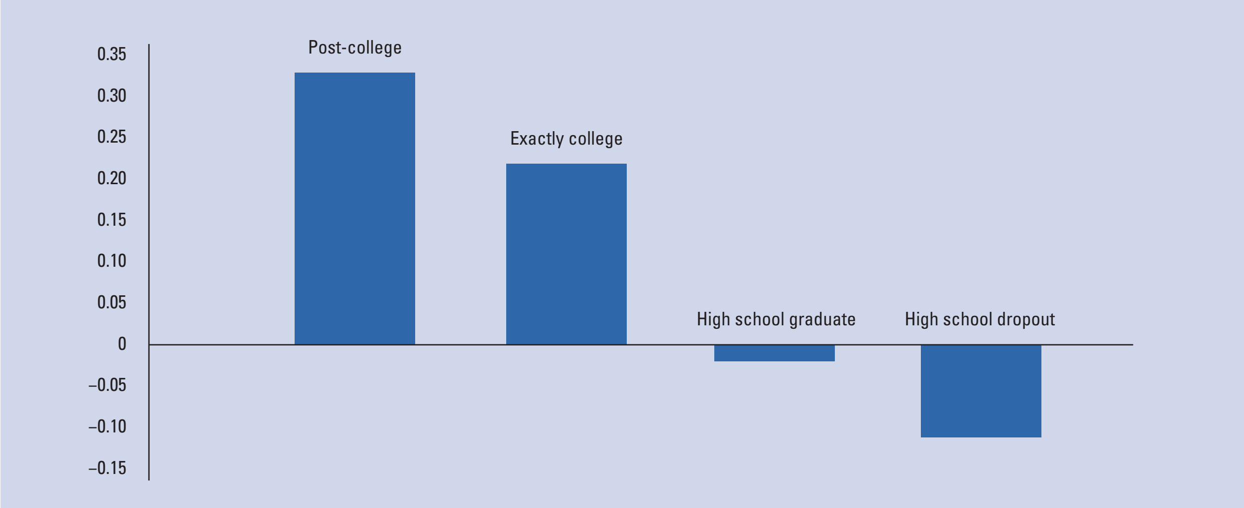
The rise of returns to superstars in the United States

We now address the changing returns to various levels of skills, primarily in the US labor market. We will then link this to the quality of Mexican education.

The demand for workers at various skill levels has changed over time. We examine the US experience in some detail, as it shows that this expansion in inequality and the rise in the returns to "quality" has, as Krugman once argued, a fractal-like aspect[16] — no matter where you look, inequality was increasing — not just between unskilled and skilled workers but within occupations, and within the top of the distribution among the educated as much (or more) than in the bottom. Labor market inequality has increased in recent decades in the United States. This increase was virtually nonexistent at the bottom, moderate in the middle, and strong at the top of the distribution.[17] That is, wage growth appears to be polarized at the high end of the wage distribution.

The most widely remarked upon research phenomenon is the rise of the premia to a college education as

Figure 4 Changes in composition-adjusted real log weekly full-time wages by level of education: United States, 1981–2005



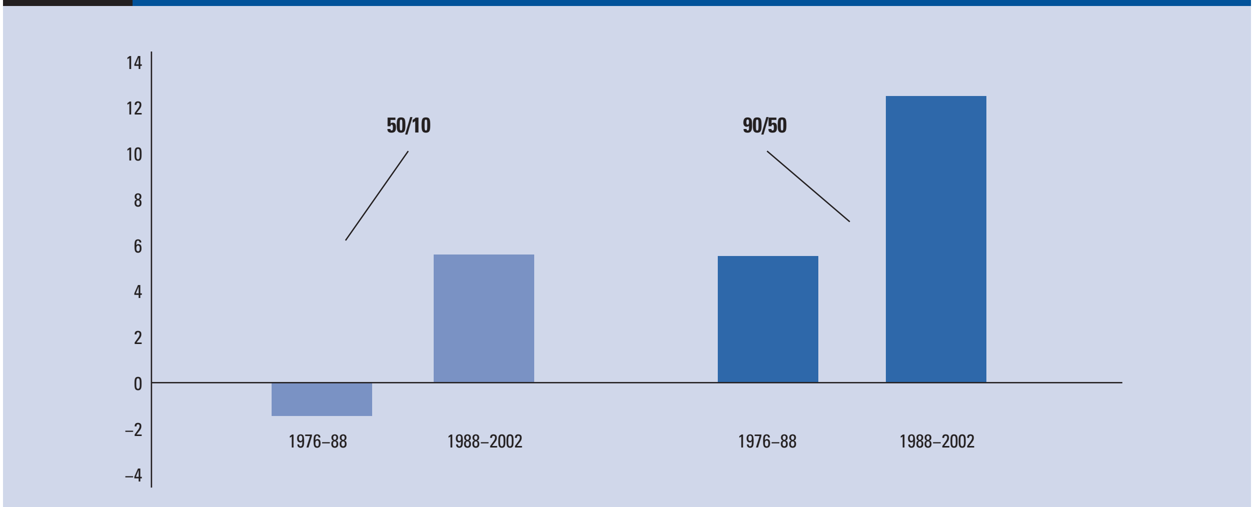
Source: Wages from Autor 2007; average years of schooling from Barro and Lee 2000

the differential growth of wages of those with and without a college degree has caused the ratios to expand. Examining the relationship between wages and education more closely, we look at the change in wages by education group (Figure 4) and can observe that both high school dropouts and high school graduates have experienced falling real wages, whereas college graduates have experienced a significant increase in labor income. Authors Autor et al. suggest that this may be partly explained by the introduction of information technology that, by complementing abstract and complex tasks, increases the demand for highly educated workers, and by being used for routine tasks, reduces the demand for less-qualified workers.[18]

However, it is also noticeable that the wages of those with a post-college degree have risen, in percentage terms, by more than those with just a college degree. This suggests that the degree of skill being rewarded does not only entail some analytical capability, but is even more than what is gained from four years of college in the United States — that is, there are higher returns for more education.

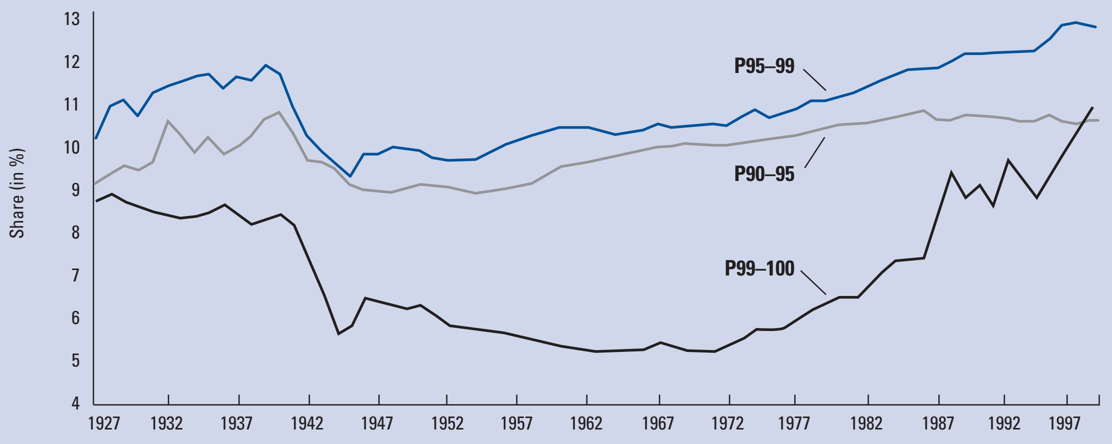
One can follow this up by examining the distribution of wages among only those who have a four-year college degree. Inequality can increase in a variety of ways, either radially and symmetrically, or asymmetrically if either the middle pulls away from the bottom or if the top pulls away from the middle. Figure 5 shows how upper- and lower-tail inequality (summarized by 90th–50th percentile and 50th–10th log wage differential) have evolved over the periods from 1976–88 and then from 1988–2002. In the earlier period, the top pulled away from the middle but the bottom gained on the middle. In the latter period (1988–2002), inequality

Figure 5 Changes (× 100) in hourly earnings inequality among college graduate males with 24–26 years of education: United States



Source: Autor et al. 2005
Note on data: March CPS 1976–2004. Statistics pool three years of data centered on indicated year. College graduates are those with 16 or 17 years of completed schooling (surveys prior to 1992) or a baccalaureate degree only (1992 forward).

Figure 6 Top wage shares in the long run: Wage income shares for 90–95th percentiles, 95–99th percentiles, and 99–100th percentiles, United States, 1927–98



Source: Piketty and Saez 2003

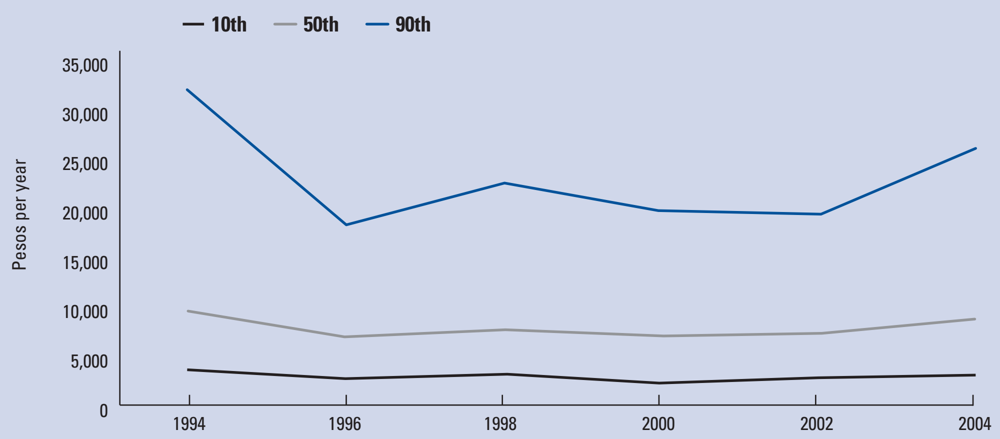
increased in both directions, but the increase of the top (90th percentile) pulled away even more rapidly from the middle. This suggests the skills that were increasingly in demand were not merely "having a college degree" but that, even among those people with a college degree, the more skilled (or at least those at the top of the earnings distribution) were even more in demand.

Finally, if we look at the long-run evolution of wages by percentile, we observe that the very top has really pulled away from the rest of the distribution. The share of total wage income going to the top 1% earners increased from lows of around 5% of total earnings to almost 10% of total wages by 1998 (Figure 6).[19]

As Rosen first suggested, the growing inequality can be explained by the fact that, thanks to modern technologies, the superstars are greatly rewarded whereas the runners-up get far less.[20] This affects the demand for skills along the distribution and causes the top to pull away from the rest.

There is evidence that this phenomenon is not limited to the United States but is taking place in the majority of the OECD countries, including Mexico. In Figure 7 we can observe that among the college graduates, those at the bottom and middle of the wage distribution have experienced a rather flat wage profile from 1994 through 2004. On the other hand, those at the high end of the distribution experienced a decline in wages after *el Error de Diciembre* because of the severe macroeconomic conditions brought on by the peso devaluation that adversely impacted better-educated workers. But, over time, trade liberalization as well as market-oriented reforms have increased demand for workers who are more educated. The demand for college graduates increased in all industries and was a result of the within-industry shifts.[21] After 2002, it is possible to observe that the top is pulling away from the middle and bottom of the wage distribution, even among college graduates.

Figure 7 Average wages among male college graduates for 10th, 50th, and 90th percentiles: Mexico, 1994–2004



Source: *Encuesta Nacional de Ingresos y Gastos de los Hogares* 1994–2004; CPI are from the IMF's International Financial Statistics

Table 3 Mexico's performance in PISA vs. selected economies

Country/ Region	Scores on the 2006 PISA	Number of student standard deviations Mexico is behind	Ratio of country/region *average* student scored to Mexican 95th percentile student score (%)
Mathematics			
Mexico	**406.00**		
United States	474	0.8	87.0
OECD average	498	1.1	91.2
Korea, Rep.	547	1.7	100.4
Science			
Mexico	**410.00**		
United States	489	1.0	89.9
OECD average	500	1.1	91.9
Korea, Rep.	522	1.4	96.0
Reading			
Mexico	**410.50**		
United States	n/a		
OECD average	492	0.86	88.0
Korea, Rep.	556	1.53	99.4

Source: PISA 2003 International Database
Note: The Mexican student standard deviations were calculated as the 5th–95th range divided by 1.642*2 (under the assumption of a normal distribution). The results were Math 84.9, Science 79.9, Reading 94.9 (the OECD student standard deviation is 100 by construction).

Implications for Mexico

In this section we compare two general points of view with regard to improving the quality of education in Mexico and its potential consequences. This comparison has two dimensions. One is that of thinking through policies and determining the degree of their impact on the *distribution* of skills. A second dimension envisions Mexico embedded in a global economy and analyzes whether Mexico's education policies will result in providing the country with a more-skilled workforce to meet the expanding demand. Let us be the first to warn the reader that we are going to make two very unpopular statements. We are going to say these things without definitive proof, but as suggestive and provocative hypotheses. They should at least be considered and examined as alternatives to the overwhelming messages about education that do not make these two points explicit.

First, there is an array of options that suggests that expanding "business as usual" policies for improving education, while possibly justified on narrow cost-benefit grounds, are unlikely to transform the quality of education. Second, radial expansions of quality from Mexico's current levels will augment a portion of the range of skilled labor for which there are at least serious questions about whether global demand is expanding fast enough.

Improve the quality of education: Trapped in a flat bowl

Let us illustrate what we mean by a *flat bowl* on a general level before delving into the specifics of the evidence about individual interventions. The illustration links three facts that are widely acknowledged but seldom considered together.

The first fact is that Mexico is far from the international frontier in terms of student quality. There are enormous differences across students in measured competencies, and hence the "student standard deviation" is very high: in the three areas of PISA, Mexico is typically between 80 and 95. Across the board, Mexico is roughly a full student standard deviation behind the OECD average (which is often roughly equivalent to the US level), and more like 1.5 student standard deviations behind cutting-edge countries such as Korea. This means that students near the very top in performance in Mexico (the 95th percentile) would be roughly the average performer in Korea; the average performer in Mexico would have to show massive improvement to be average in the United States or Korea (Table 3).

The second fact is that the absolute *magnitude* of the learning gains that are demonstrated in the typical proposed educational improvement scheme are very small.[22] The literature on education often uses effect sizes in order to have a common metric for evaluating the magnitude of learning gains (otherwise test instruments with different absolute scales would have different apparent absolute impacts).[23] The typical effect size in the literature of the standard "business as usual" expansion of inputs is roughly zero. No definitive conclusion has been reached by scholars on what education policies and reforms may be most effective in improving the overall quality of schooling. There is certainly no clear causal relationship between expenditure and students' achievement.[24] This does not mean either that "money does not matter" or "money cannot matter."[25] On the other hand, this lack of causality reveals the importance of making an effective use of resources to produce positive results. In this regard, there is general agreement on which basic aspects of education need to be addressed, such as the importance of teaching quality, the need for standards and accountability, and the possible benefits of incentives and market-oriented reforms. However, empirical findings are not conclusive and often show that the impact of a specific policy is highly dependent both on the context of the institution where the reform is implemented and on the time of assessment.

In what follows, we provide an overview of significant education policies, most of which have been recently implemented in Latin and Central America to improve the quality of schooling. These policies can be grouped according to their focus under three categories: teacher quality, resources, and school-based management reforms.

Thus, even when it comes to available options about which there is even semi-conclusive evidence about their efficacy in actually raising scores, these options do not provide a definitive guide for substantial improvements in performance. The magnitude of their impact, even of those that are demonstrated to be statistically different from zero, is often very small. The effect size of a tenth of a standard deviation of an intervention of any kind is considered very large.

The third fact is that, even once one finds interventions that have a substantial effect size, the scope for the application of the intervention is often limited. Many proposed interventions are remediation of shortages (e.g., ways to address large class sizes, undertrained teachers, lacking facilities). But in these cases, the impact on the total or average score is the treatment effect times the potential scope of the treatment. For instance, suppose one found that underqualified teachers could be brought up to par with training. Then the total gain is the gain per trained teacher times the number of potentially trainable teachers. So, even if the training were to show an effect (which it often does not), and even if this has a huge effect size of 0.1 (which is even less plausible), then if this training is effective in 20% of the teachers, it adds up to a gain of 0.02 student standard deviations.

The upshot is that the *trip is long, the vehicle is slow, and you are almost out of gas*. We again illustrate this principle — although it is not concrete proof — by examining the empirical magnitudes of the potential gains from the type of educational reforms being discussed in Latin America generally. We then summarize the potential gains to be realized in Table 4 and Figure 8.

Performance-based pay bonuses for teachers

Teachers play a key role in students' learning,[26] and teachers' salaries represent the largest share of educational expenditure. This is why teacher incentive reforms are one of the main challenges for education faced by Latin American countries. Two programs have been recently implemented in Mexico and Chile that aim to improve teaching quality by providing teachers with bonuses linked to their performance. The *Carrera Magisterial* was introduced in Mexico in 1993 to modernize primary schooling. Among other things, the program replaced the five-year-seniority teacher pay scale with a new pay structure where improvements in students' performance represented 20% of the total weight.[27] It consisted of a promotion system where teachers and principals are evaluated on an individual basis. Empirically, no positive effect has been found on students' performance; this may be partly because of the weak incentives provided for teachers and the significant role played by unions in determining the teachers' pay increases.[28]

The Chilean program introduced in 1996, *Sistema Nacional de Evaluación de Desempeño de los Establecimientos Educacionales* (SNED), seems to have been more effective. A group-based incentive is assigned to the highest-performing schools that enroll at least 25% of students in each region; this award represents 5–7% of teachers' annual wages and assigns a great weight to improvements in students' performance in determining teachers' award: 28%. Moreover, the effectiveness of students' performance is included in the evaluation and counts for 37% of the total weight.[29] There is evidence of the positive effect of this reform on students' performance, especially for those schools more likely to win the award.[30] The reforms undertaken in Chile and Mexico show that the political context and the unions play a significant role in their design and implementation.[31]

Finance equalization

The *Fundo para Manutenção e Desenvolvimento do Ensino Fundamental e Valorização do Magistério* (FUNDEF) was introduced in Brazil in 1998 to reduce the inequality of the educational system. Specifically, FUNDEF's main aim was to redistribute resources from the richer to the poorer regions and to increase the wages of public teachers. The program has indeed led to an increase in teachers' wages and to a relative improvement of the public schooling system,[32] as well as an improvement in the educational system for specific demographic groups.[33]

Class size reduction

Of the existing studies, 75% have found no effect from a decrease in the pupil-teacher ratio on students' performance.[34] Among the remaining 25%, the evidence is mixed.[35] While redistributing revenue, FUNDEF led to changes in educational inputs — in particular, to a reduction in class size. The available empirical evidence does not show improvement in students' performance resulting from this reduction.[36] To estimate the largest possible gain from this policy, we can consider Krueger's evaluation of Project STAR, an experiment carried out by the US state of Tennessee in the mid 1980s that involved a comparison of achievement by students randomly assigned to classes of different size. Krueger finds significant and large gains from a reduction in school size.[37]

School awards

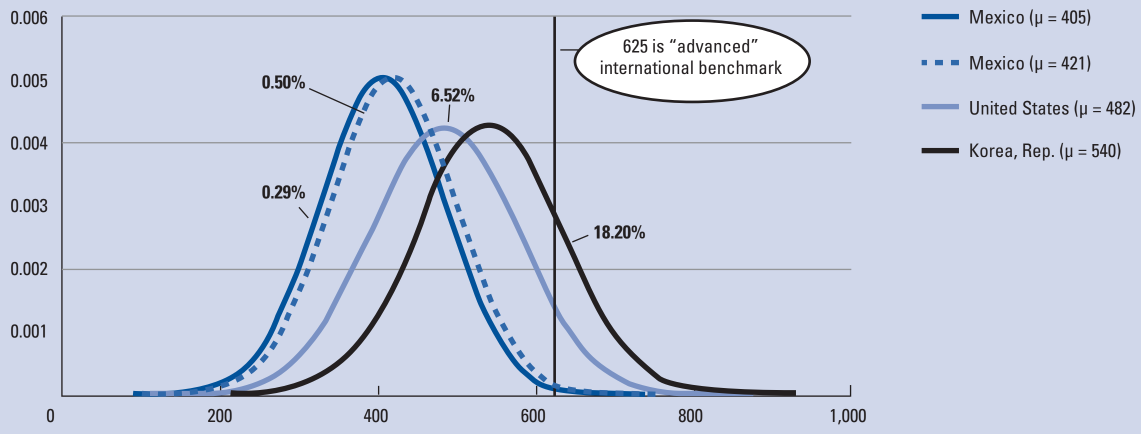
These award incentives have been only recently introduced in Latin America, so most of the existing programs have not yet been evaluated. The few assessments conducted, however, show that the collective incentives appear to be more effective than the individual ones, as they promote cooperation to achieve common objec-

Table 4 Policy interventions, effect size, and maximum gain

Intervention	Examples	Effect size on students' performance	Maximum gain
Teacher quality			
Performance-based pay bonuses for teachers	*The Sistema Nacional de Evaluación de Desempeño de los Establecimientos Educacionales* (SNED) was introduced in Chile in 1996. Among the objectives, improvement in teacher quality occupies a privileged position. It offers bonuses to schools that show excellent performance in terms of students' achievement; 90% of the SNED bonus is divided by teachers in the school (this represents 5–7% of the annual wage).	Positive impact on students' achievement especially in those schools more likely to win an award. Also positive effects on teachers' attitudes and quality of entrants into teacher education programs increased. (Mizala and Romaguera, 2005)	0.05 increase in school performance; teachers' average salaries rose 156% from 1990 to 2002.
	Carrera Magisterial was introduced in Mexico in 1993. It provides teachers with large financial rewards that are based, among other factors, on students' test scores. Participation is on a voluntary and individual basis.	None (not robust). (McEwan and Santibanez, 2005)	
Resources			
Finance equalization	The *Fundo para Manutenção e Desenvolvimento do Ensino Fundamental e Valorização do Magistério* (FUNDEF) was introduced in Brazil in 1998. It aimed to promote greater equity in educational opportunities between states and across municipalities by providing a minimum per pupil expenditure in primary schools throughout the country.	Mixed: Reduction in spending inequality positively affects nonwhite students and students at the bottom of the distribution (Gordon and Vegas, 2005). Improvements in students' test scores for students in public schools with respect to their counterparts in private schools appear to be partly related to teachers' increased wages. The effects appear to be concentrated in the northeastern part of the country. (Menezes-Filho and Pazello, 2004)	0.05 increase in school performance; teachers' average salaries rose 156% from 1990 to 2002.
Class size reduction	The *Student-Teacher Achievement Ratio* (STAR) was a randomized experiment undertaken in Tennessee in the 1980s.	Positive and significant effect on students' performance. (Krueger, 1999)	0.2 standard deviations of test performance in reading and math
	FUNDEF: increased resources were partly used to reduce class size in Brazil starting in 1998.	No effect. (Gordon and Vegas, 2005)	
School-based management reforms			
Performance-based pay bonuses for principals	*Carrera Magisterial*, introduced in Mexico in 1993, allows principals to receive an award based on the overall performance of their school. Participation is on a voluntary and individual basis.	None (not robust). (McEwan and Santibanez, 2005)	
School awards	The *Incentivo Colectivo a Escuela* (ICE) was introduced in Bolivia in 2001 to encourage collaboration between principals, teachers, and staff in primary schools.	No assessment available of the effects on students' performance.	
	The *Plan de Estímulos a la Labor Educativa Institutional* (PLAN) was introduced in El Salvador in 2000 to encourage public school teachers to work together to solve the problems affecting their schools and improve the quality of educational services that they offer the community.	No assessment available of the effects on students' performance.	
	SNED bonus (10%) is given to schools as an "excellence subsidy."	See discussion in text.	
School autonomy	The *Educación con Participación de la Comunidad* (EDUCO) Program was established in El Salvador in 1992 with the aim of increasing decentralization and delegating the decision-making authority of pre-schools and primary schools to community organizations and parents.	Positive effects on teacher behavior. Teachers may have more motivation (demonstrated by dedicating more time to teaching, being absent less, and by spending more time meeting with the parents, for example). There is no conclusive evidence on the effects of these policies on students' performance. (Sawada and Ragatz, 2005)	
	Autonomia Escolar started in Nicaragua in 1993. It introduced decentralization of the schooling system with a financial-administrative focus.	Differences between autonomous and centralized schools do not seem to affect students' outcomes; results are not robust to different specifications. (Parker, 2005)	

Source: Authors' elaborations based on Gordon and Vegas 2005; Krueger 1999; McEwan and Santibanez 2005; Menezes-Filho et al. 2004; Mizala and Romaguera 2005; Parker 2005; Sawada and Ragatz 2005; Vegas 2005

Figure 8 Simulated effect on the PISA 2003 mathematics scores of the maximum possible effect of class-size reduction



Source: PISA 2003 International Database

tives.[38] The programs implemented in Latin America differ in their structure and requirements. The school award introduced in Bolivia in 2001 aims at providing a monetary compensation to teachers, principals, and staff based on the overall improvement of school performance. In the framework of the school award PLAN implemented in El Salvador, standards are set by the Ministry of Education and school personnel are remunerated accordingly.[39] In addition to the teachers' award previously described (which represents 90% of the SNED bonus), the Chilean program provides the remainder of the bonus to schools as an "excellence subsidy." Schools have autonomy with respect to the use of this award.[40]

Only the very costly and highly controversial class-size policy appears to have had a substantial effect on students' achievement, as found by Krueger in the 1980s experiment in Tennessee with students randomly assigned to different class sizes; even then the effect was concentrated.[41] When the other policies are effective, they appear either to have a moderate effect or to improve the performance of specific groups of students. If we do not consider any issue related to the reliability and external validity of Krueger's 1999 study,[42] and we relate the effect of smaller class-size policy to the distribution of test scores presented earlier in Figure 1, we can observe that, at best, the class-size policy would lead to a modest gain in the mean test score.

Even in this best-case scenario, if those interventions were able to increase quality by 0.2 student standard deviations — and it is worth stressing again that these standard deviations are at the outer range of any class-size effects estimated nearly anywhere, and that achieving these gains would be costly and take a long time — the average *quality* of education in Mexico would remain far below the quality of education in Korea and the United States. The percentage of Mexican students testing above the international benchmark would increase from 0.29% to 0.50% (Figure 8). Hence, in the low estimate, the total number of global high performers would increase from 3,500 to only 6,000 — after years of effort and huge increases in expenditures, one would need a slightly larger auditorium to hold the global high performers.

Expansion of business as usual

Another popularly recommended educational policy is schooling expansion. In much of Latin America, this constitutes a call for turning higher and higher levels of secondary schooling universal. Increasing the average education level of the Mexican population would imply expanding primary and secondary education over tertiary. There are many reasons one might want to make secondary schooling universal, and that is a social policy that Mexico may wish to pursue.

The question we raise is whether universal secondary schooling would likely have much impact on Mexico's economy or economic performance. Consider the global demand and supply for various types of skills and skilled labor. If one is producing manufactured goods, then one is coping — as are all countries — with the massive expansion of the relatively low skilled labor pool linked to the addition, first by China and then India, of their billion-person populations to the effective supply of unskilled and semi-skilled labor. Any sustained wage advantage over these economies must be grounded in higher-productivity labor that leads to competitive unit labor costs. The question, for which we have no answer or evidence, is whether moving the typical Mexican worker from 8 to 9 or 9 to 10 years of schooling is going to make a substantial difference in the dynamism of the Mexican economy. This is expanding the supply of a factor that world markets (for tradables, which impact labor markets) have been suggesting is hardly in excess demand.

If one is not competing for producing manufactured goods — the application of routine manufacturing production techniques to add value — then perhaps one can compete in the market for *ideas* that, broadly defined, is the addition of value through design, invention, innovation, creativity, first-mover advantages, and so on. In the market for ideas in tradables (either directly, as in service industries such as finance, or indirectly, in creativity embedded in goods) one is competing with the United States and other advanced-market economies (and, in fields such as engineering, East Asian economies). Again, the question should be whether the expansion of the education of the typical young person from 8 to 9 years of school at existing (or feasible) levels of quality will really transform Mexico's ability to raise productivity in the global market for ideas. As we demonstrated above, one of the key social issues in the United States is that among college graduates the demand for skills was shifting toward the upper tail of skills. The markets for ideas often display superstar features.

Discovering the discoverers

We do not wish to overstate our case. We merely suggest a new range of policies that should be taken into consideration in discussions about which education policies should be pursued. We are suggesting that, however desirable for social policy reasons educational policies aimed at addressing broad-based quality and promoting equality of access are (and we have no issue with these arguments), they are unlikely to be of great economic significance in the short to medium term. This is just pointing out the unpleasant but obvious—during all of the lost decades of stagnating (or falling) levels of output per worker in Latin America, average levels of educational attainment moved steadily upward. If the business-as-usual expansions of existing educational systems were capable of producing growth acceleration, then the impacts should have been widely noticeable by now.[43]

What we are proposing is to at least consider policies that have the following three features:

1. encouraging better performance among the top performers,
2. emphasizing broadening the base of talent across socioeconomic groups by proactively identifying and encouraging academic excellence outside the group of students who are currently affluent, and
3. creating an environment conducive to entrepreneurship so that new ideas in the production of tradables can flourish.

Discovering the discoverers

The adoption of imitative technology requires a country to develop the social capability to effectively adapt and use the technologies in their production system.[44] That is, the transfer of existing technology needs the appropriate institutions to be successful and entrepreneurs who decide how to use it in the most effective way, given the other inputs of production.[45] Optimal production strategies greatly differ across sectors. To produce manufactured goods, Mexico must be able to compete with China and Vietnam; to produce low-end portable services, Mexico must be able to compete with India and Ireland, while to be able to produce high-end ideas, Mexico must be able to compete with the United States and Israel.

Thus, to foster economic growth, a country has to "learn what it is good at producing."[46] The level of education of the workforce affects what there is to be discovered in a country's capability set as discoverers lead "self-discovery." In the process of Schumpeterian entrepreneurship, one needs a critical mass of people of high ability to put together factors in a new way. And Mexico is failing to achieve this.

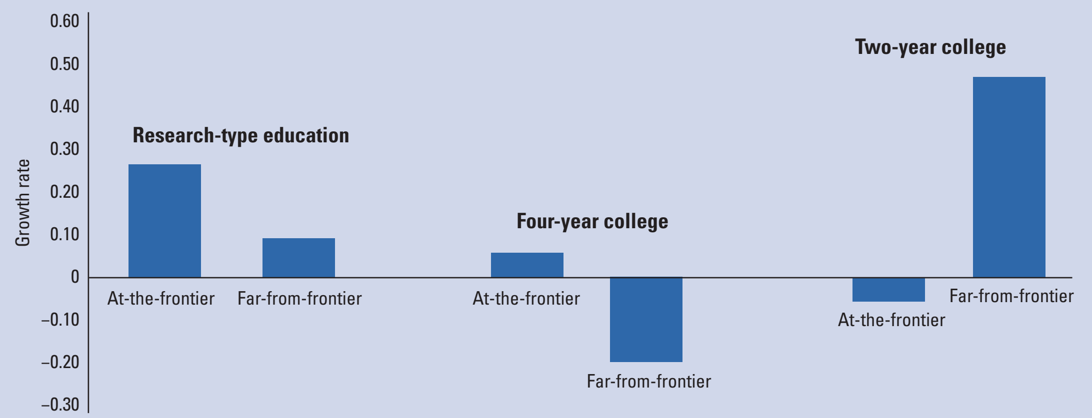
Aghion et al. have shown how the composition of its human capital and its distance from the technological frontier affect a country's economic growth.[47] They show that countries closer to the frontier may benefit the most from investment in research education because this may foster the creation of knowledge and the process of innovation. On the other hand, research education can also have a significant impact on growth and development in countries far from the frontier. In the case of the United States, even in far-from-the-frontier states, increased spending in research-type education has a positive effect on economic growth (Figure 9). As described in the previous section, even in Mexico the superstar phenomenon shows that returns to the top are high and the demand for highly educated and able workers is increasing.

Expansion of opportunity by identifying talent

Some 45.1% of the population aged 15–19 years is not in school in Mexico.[48] Only 62% of those not in school are employed; the remaining 38% are not engaged in any productive activity (i.e., employment, education, or training). As we can see from Figure 10, educational attainment stratifies sharply on household income: only half the poorest 20% even reach ninth grade.

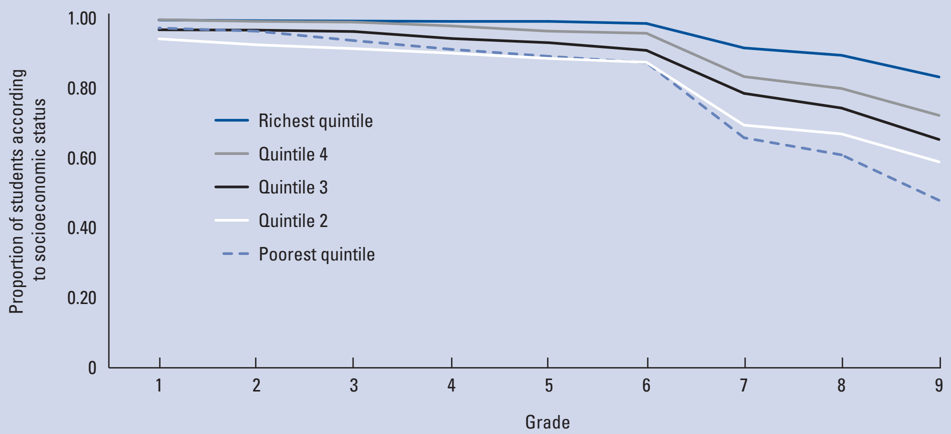
This means that not even all children in the age cohort are taking the PISA test. This implies that, by selecting students for the PISA on the basis of socioeconomic status, not ability, Mexico is recruiting from a narrow base. If potentially high-ability children from low-income backgrounds drop out, there is a loss to the pool of potential discovers. Mexico would never attempt the *Mundial de futból* by selecting players only from a small stratum of the population; why is Mexico attempting to do this with the *economic Mundial*?

Figure 9 Effect on per-employee growth rate of US$1,000 per person in additional spending at different levels of education in states near and far from the technological frontier



Source: Aghion et al. 2005

Figure 10 Educational attainment profile, ages 15–19, by per capita household groups



Source: http://econ.worldbank.org/projects/edattain/
Note: Groups from per capita household expenditures are based on analysis of data from IHS-WDR07.

Allocation of talent to global tradables

All these factors combined significantly affect the allocation of talents — that is, the relationship between the reward structure of a society and the way individuals allocate their talent between productive and unproductive activities. The allocation of talent in a society is an important determinant of output and growth. Murphy et al. show how, although general talent is not occupation-specific, its allocation critically depends on the returns to ability between different sectors and the set of incentives faced by individuals.[49] That is, if we exclude those individuals who have exceptional natural talent for a specific task, such as singing opera or playing basketball, we are left with other individuals who may have higher intelligence and ability that gives them a competitive advantage in any occupation they choose. In the case of Mexico, highly educated individuals would choose professional activities insulated from international competition because of the low-average quality of the education they received at secondary and tertiary levels. These are the non-tradable occupations described in Table 5.

Moreover, the institutional setting, legal framework, and social status attached to different occupations will affect how individuals choose their professions. As previously shown, education in Mexico is stratified by income and ability to pay, not by talent and intellectual ability. This reinforces not only the lack of emphasis on expanding high-quality education, but also perpetuates low social mobility and great inequality. This selection process also affects the way individuals perceive the fairness of institutions and how society rewards their effort and commitment. A self-replicating elite is more likely to be in favor of the status quo. Therefore, productive

Table 5 The allocation of talent

Type	Tradable	Non-tradable
Innovation	Growth-enhancing professions (e.g., entrepreneurs, engineers, designers)	Nationally regulated professions (e.g., doctors)
Re-distribution		Rent-seeking professions (e.g., lawyers, lobbyists)

ability may be less socially valuable than rent-seeking behavior.[50] In these circumstances, therefore, talent would end up being concentrated in the non-tradable and rent-seeking activities (Table 5). These are the low-growth professions as opposed to growth-enhancing ones. If institutions do not encourage private initiative, social mobility, and productive activities, then talented individuals will choose occupations that do not face competition; low-quality education in international terms means there is a high ability assigned to non-tradable occupations to limit competition. This would create a significant distortion in the allocation of people, because highly productive individuals would choose socially unproductive occupations.

We are aware that these views fly in the face of the vast majority of recommendations about education. Again, we are not disputing that the usual recommendations — which tend to focus on system expansion in access; broad-based improvements in quality; and, if anything, reducing inequality in outcomes by focusing on the low-performing schools and students — are correct as educational policies for a variety of social and internal educational reasons. However, the typical (average scoring) Mexican 15-year-old student is roughly at the 18th percentile of the skills distribution of OECD 15-year-olds. Moreover, that is roughly average school completion in Mexico, while other countries have much higher average completion levels. So the typical school leaver and labor market entrant in Mexico is probably near the bottom 10–15% of the skills distribution of the typical labor market entrant in the United States or other OECD countries. It is difficult to believe that the available marginal and gradual improvements in the skills of the typical school leaver will have immediate, growth-accelerating effects by in any way facilitating a structural transformation in the Mexican economy or an expansion in productivity.

Conclusion

Education, research, scientific discovery, innovation, and economic growth are closely related. This chapter has shown that traditional education policies that focus on expanding the educational system at the *average*, while they may have many benefits, are unlikely to make Mexico competitive in the knowledge-based global economy. On the other hand, the chapter has suggested exploring measures to enhance the country's productive capabilities and foster economic growth. An effective development strategy would not simply raise the *average* schooling levels of the population, but would rather enhance the *top*. In this regard, a combination of focus on the upper tail and on the expansion of opportunity is needed to enable Mexico to compete globally. The emphasis should be on both "discovering the discoverers" by developing the educational system based on the quality accessible to the top and fostering global standards of performance, and on proactively identifying low-income, high-ability individuals to facilitate educational and economic mobility.

Notes

1 See Santibañez et al. 2005, p.17. This is calculated by taking completion indicators of the *Secretaria of Educación*, 2003. There are no data on how many of the upper secondary graduates enter college.

2 Villa and Pacheco 2004 and Santibañez et al. 2005.

3 The latest paper on this topic is that of Hanushek and Woessmann 2008. The literature about the role of schooling attainment (aggregated into measures of "schooling capital") on economic growth has shown mixed results, with the contribution to aggregate output at best equal to the contribution one would have expected from the microeconomic returns; see Pritchett 2006.

4 Developed jointly by OECD member countries through the OECD's Directorate for Education, PISA aims to measure how far students approaching the end of compulsory education have acquired some of the knowledge and skills essential for full participation in the global economy. The PISA test is conducted every three years with 15-year-old students across more than 50 countries to assess their scholastic capabilities in reading as well as their mathematic and scientific literacy. For more information, please see: http://www.pisa.oecd.org/.

In this chapter, data from PISA 2003 were used instead of the most recent 2006 data since the main focus of that year's test was on mathematics as opposed to science for the 2006 edition. That is, in each edition of the PISA assessment one of the three domains (reading, mathematics, science) is examined in depth. It was believed more appropriate for the purpose of this chapter to use the results of PISA 2003 to examine students' performance in mathematics, since in PISA 2006 mathematics was only a minor subject of assessment. Moreover, it is important to note that the mathematics test scores from PISA 2006 are consistent with the data from PISA 2003; the relative ranking of Mexico, the United States, and Korea remains unchanged.

5 We show here the figure for mathematics only because it appears to be the most readily comparable subject across countries. Analogous figures for science, reading, and problem solving are available from the authors upon request, at: Lant_Pritchett@hks.harvard.edu, Martina_Viarengo@hks.harvard.edu

6 These are: level 1 (358–420), level 2 (420–482), level 3 (482–545), level 4 (545–607), level 5 (607–669), and level 6 (above 669). In order to be assigned to a level of proficiency, a student must provide the right answer to the majority of the questions of the related level. See Table A1 in Annex A for a description of the students' skills and knowledge at each level of proficiency.

7 PISA 2003, p. 11.

8 PISA 2003, Technical Report (p. 261). Refer to Table A1 in Annex A for a description of the other levels of proficiency.

9 PISA 2003, Technical Report (p. 261). This corresponds to levels of proficiency 5 and 6.

10 Since the test is constructed to have mean 500 and standard deviation 100, the level 625 is roughly at the tenth percentile.

11 See Filmer et al. 2006 for work done in connection with calculating the number of students above a potential Millennium Development Goal that constructs cohert estimates from tested students and learning profiles.

12 These calculations are based on a recent paper using TIMSS questions given to students in only two states of India, extrapolated to the national level. Although these calculations are the best that can be done, they are far from "official" and should be taken as rough approximations.

13 In 2005, the website that listed the results was not functional. Coincidentally, the 2005 contest was held in Mexico.

14 One can simulate the differences in averages that would be consistent with the observed differences among the top six students assuming they are drawing from populations proportional to the cohort sizes. A simulation based just on these Olympiad scores produces inferred differences in central tendency (assuming equal variances) consistent with the rankings of large-scale tests for these countries — for example, it shows that the Slovak Republic has much better average scores than Thailand or India but does worse only because of size.

15 Santibañez et al. 2005, p. ix.

16 Krueger 1999.

17 Autor 2007.

18 Autor et al. 2005.

19 This appears even more striking when we look at how fast the relative change has occurred: in 1970, 0.01 percent of taxpayers only earned 70 times as much as the average; in 1998, the richest 13,000 US families had incomes 300 times greater than the average family; see Krugman 2002.

20 Rosen 1981.

21 Cragg and Epelbaum 1996.

22 See Filmer and Pritchett 1996; Pritchet, 2004.

23 This far from solves the problem, as even the student standard deviation depends on the underlying evaluation instrument — a test that was far too hard for the tested population might return as very low student standard deviation because the scores cluster on zero. Often in empirical studies the standard deviation of the assessment is itself normalized and then impacts are reported as effect sizes, but the effect sizes may or may not be comparable.

24 Hanushek 2003, 2006.

25 Hanushek 2007, p. 9.

26 Hanushek at al. 2005; Vegas and Umansky 2005.

27 Mizala and Romaguera 2004, Table 2.

28 Vegas 2005.

29 Mizala and Romaguera 2004, Table 2.

30 Vegas 2005.

31 Vegas 2005.

32 Menezes-Filho and Pazello 2004.

33 Gordon and Vegas 2005.

34 Hanushek 2007.

35 Surveys of the evidence on class size include Hanushek 1986, 1996; Card and Krueger 1996.

36 Gordon and Vegas 2005.

37 Krueger 1999. We acknowledge the limitations of Krueger's study; see Hoxby 2000; Hanushek 2007. The purpose here is only to show the maximum possible gain in case the policy was effective.

38 Mizala and Romaguera 2004.

39 Mizala and Romaguera 2004.

40 Mizala and Romaguera 2005.

41 Krueger 1999.

42 A study by Woessmann 2003 summarized in Pritchett 2004 shows that, even using plausible techniques for identifying the causal impacts of class-size reductions and examining the evidence across more than a dozen OECD countries using the TIMSS data, *none* of them find an effect as large as Krueger suggests and most of them are very near zero. Although identification is an issue, even class-size impacts identified with randomized experiments in contexts such as India and Kenya find essentially no effect.

43 Pritchett 2006.

44 Abramovitz 1986, p. 387.

45 Hausmann and Rodrik 2003 describe how, even in the case of complete information on technology, entrepreneurs would play a key role in deciding what to produce with it.

46 Hausmann and Rodrik 2003.

47 Aghion et al. 2006.

48 OECD 2008, p. 22.

49 Murphy et al. 1991.

50 This refers to "the socially costly pursuit of wealth transfers"; see Tollison 1997, p. 506.

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Annex A

Table A1 PISA 2003: Levels of Mathematics Proficiency

6	At Level 6 students can conceptualise, generalise, and utilise information based on their investigations and modelling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply their insight and understandings along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for attacking novel situations. Students at this level can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situations.
5	At Level 5 students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations, and insight pertaining to these situations. They can reflect on their actions and formulate and communicate their interpretations and reasoning.
4	At Level 4 students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilise well-developed skills and reason flexibly, with some insight, in these contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
3	At Level 3 students can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They can develop short communications reporting their interpretations, results and reasoning.
2	At Level 2 students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures, or conventions. They are capable of direct reasoning and making literal interpretations of the results.
1	At Level 1 students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are obvious and follow immediately from the given stimuli.

Source: OECD. PISA 2003 Technical Report. 2005, p. 261, figure 16.4. Available at http://www.pisa.oecd.org/dataoecd/49/60/35188570.pdf
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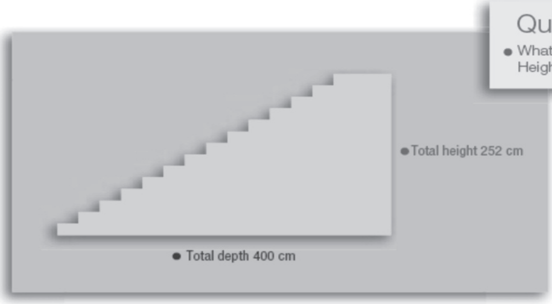
Annex A (continued)

Table A2 PISA 2003: Mathematics, sample questions

STAIRCASE

The diagram below illustrates a staircase with 14 steps and a total height of 252 cm :



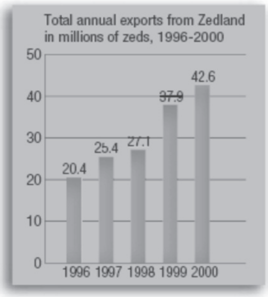
Question

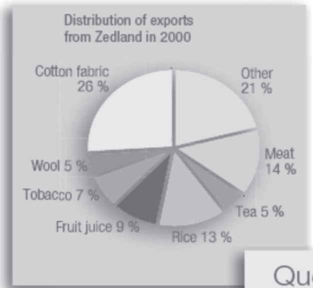
- What is the height of each of the 14 steps?
  Height: .... cm

This short response question is situated in a daily life context. The student has to interpret and solve the problem which uses two different representation modes: language, including numbers, and graphical. This question also has redundant information (i.e., the depth is 400 cm) which can be confusing for students, but this is not unusual in real-world problem solving. The actual procedure needed is a simple division. As this is a basic operation with numbers (252 divided by 14) the question belongs to the reproduction competency cluster. All the required information is presented in a recognisable situation and the students can extract the relevant information from this. The question has a difficulty of 421 score points (Level 2).

EXPORTS

The graphics below show information about exports from Zedland, a country that uses zeds as its currency.





This multiple-choice question is situated in a public context and is in the uncertainty content area. It consists of reading data from a bar chart and a pie chart, and combining that data to carry out a basic number operation. Specifically, it involves decoding the charts by looking at the total of annual exports of the year 2000 (42.6 million zeds) and at the percentage coming from Fruit Juice exports (9%). It is this activity and the process of connecting these numbers by an appropriate numerical operation (9% of 42.6) that places this question in the connections competency cluster. The question has a difficulty of 565 score points (Level 4).

Question

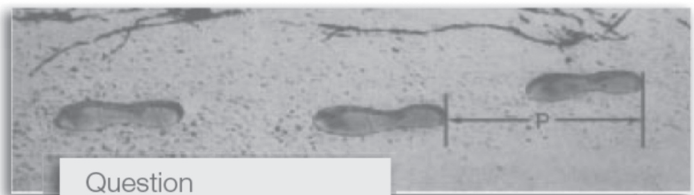
- What was the value of fruit juice exported from Zedland in 2000?
  A. 1.8 million zeds.
  B. 2.3 million zeds.
  C. 2.4 million zeds.
  D. 3.4 million zeds.
  E. 3.8 million zeds.

WALKING

The picture shows the footprints of a man walking.
The pacelength P is the distance between the rear of two consecutive footprints.

For men, the formula, $\frac{n}{P} = 140$, gives an approximate relationship between n and P where:

n = number of steps per minute, and
P = pacelength in metres.



Question

- If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

This open-constructed response question is situated in a personal context. The question is about the relationship between the number of steps per minute and pacelength, which means that it is in the change and relationships content area. Students need to solve the problem by substitution into a simple formula and carrying out a routine calculation: if n/p = 140, and n = 70, what is the value of p? The competencies needed involve reproducing practised knowledge, performing routine procedures, the application of standard technical skills, manipulating expressions containing symbols and formulae, and carrying out computations. With this combination of competencies, and the real-world setting that students must handle, the question has a difficulty of 611 score points (Level 5).

Source: OECD. *First Results* from PISA 2003, pp 6–7. Available at http://www.pisa.oecd.org/dataoecd/49/60/35188570.pdf
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Annex A (continued)

Table A3 PISA 2003: Number of students above the advanced international benchmark in mathematics

Country	Percent of total test takers	Number of test takers	Cohort size
India*	52.3	11,503,247	21,994,737
Korea, Rep.	97.2	681,426	701,056
Mexico	60.0	1,204,632	2,007,721
Slovak Republic	75.0	63,821	85,095
Thailand	71.2	727,055	1,021,145
United States	88.0	3,676,652	4,178,014

Country	Percent of test takers scoring > 625	Number of test takers scoring > 625	Cohort size
India*	1.00	95,659	21,994,737
Korea, Rep.	18.20	127,592	701,056
Mexico	0.29	5,822	2,007,721
Slovak Republic	9.42	8,016	85,095
Thailand	1.51	15,419	1,021,145
United States	6.52	272,406	4,178,014

Source: UNESCO Statistical Yearbook; PISA 2003; World Bank, 2003

* TIMSS 2003 estimate for India is 101,000; here it is adjusted by the US TIMSS/PISA ratio and is equal to 95,659. This is because India did not participate in PISA 2003, so we are using test scores directly comparable to the TIMSS 2003 developed by Das and Zajonc (2008) and adjusting them to account for the differences between TIMSS and PISA (TIMSS is taken by 4th and 8th grade students and has questions more closely related to the curriculum, whereas PISA is taken by 15 -year-old students and measures literacy in the subject.)

Note: Percent of test takers = gross enrollment in secondary education in the country (net enrollment data were not available for the Slovak Republic); test takers as percent of cohort = percentage of test takers in the math test as a share of the total number of 15-year-olds in the country; percent of test takers scoring > 625 = percentage of test takers who achieved a score greater than 625 in the math test; test takers scoring >625 as percent of cohort = percentage of test takers who achieved a score greater than 625 in the math test as a share of the total number of 15-year-olds in the country; and cohort size = total number of 15-year-olds in the country.